ISROMAC 2017
International Symposium on Transport Phenomena
and Dynamics of Rotating Machinery
Maui, Hawaii
December 16-21, 2017

[Extended Abstract]

Commissioning of a Test Stand for Turbocharger Investigations at Constant Turbine Inlet Temperatures

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Introduction

Design parameters of state of the art turbochargers evolve towards slender rotating components due to cost and operation mode efficiencies. Slender rotating components increase transient response characteristics due to lower inertia and therefore, improving performance and efficiency. To evaluate the operational characterisitcs of a turbocharger at different turbine inlet temperatures, a test stand was developed at the Institute for Power Plant Technology, Steam and Gas Turbines (IKDG) to enable the investigation of performance maps at selectable constant turbine inlet temperatures. To reproduce real time applications where turbochargers are implemented downstream the exhaust outlet of an engine, a lot of test stands use loop operation where the compressed air of the turbocharger compressor passes a combustion chamber upstream of the turbocharger turbine [1, 2]. By decoupling the mass flows of turbocharger compressor and turbine, a wider range of the performance map can be investigated. Furthermore this makes operating the turbine at constant inlet temperatures much easier. Therefore turbocharger test stands have been developed where the turbocharger turbine is operated without using the compressed air mass flow from the turbocharger compressor [3, 4]. A significant difference between these test stands and the test stand introduced in this paper, is the use of two hot gas generators that run sequentially. By this means the turbine inlet temperature can be adjusted with a maximal deviation of about +/- 1.0K during steady state operation.

In this paper, the IKDG test stand design is evaluated. The test turbocharger is thermodynamically examined in regard of operation at 220°C turbine inlet temperature. An overview of the measurement instrumentation is given and the thermodynamic parameters of the turbocharger necessary for generating a power map, are presented. Additionally, an uncertainty analysis of the temperature and pressure measurement according to DIN V ENV 13005 and [4] is conducted. Based on these results, a performance map of the compressor as well as the turbine of the turbocharger is generated and discussed.

1. Test stand setup

The test turbocharger is designed for usage in marine engine applications and is provided by Kompressorenbau Bannewitz GmbH (KBB). The turbocharger provides a total compressor pressure ratio

of up to 5.5 with a maximum turbine mass flow rate of 5.7kg/s at a certain inlet temperature of 220°C. This allows the determination of the turbocharger efficiency at below usual real time application. This temperature operation was chosen to additionally conduct transient pressure and aerodynamic excitation measurements which will be presented in another paper. The test turbocharger is designed for turbine inlet temperature operation up to 650°C. The test stand consists of different subsystems composed of air supply infrastructure, air heater components, test turbocharger, data acquisition system and control unit. Figure 1 shows a simplified flow diagram of the turbocharger test stand at the IKDG facility with the instrumented measurement planes (MP).

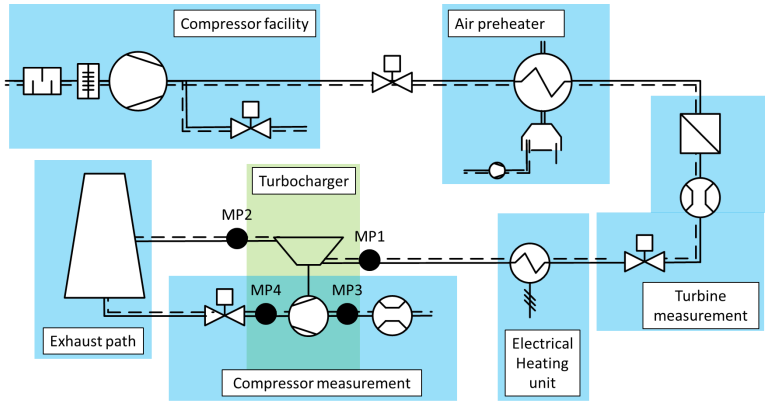

Figure 1. Overview of the test stand at IKDG with instrumented measurement planes

2. Measurement setup

The measurement instrumentation comprises the acquisition of the thermodynamic operating conditions of the turbocharger as well as the rotational speed and the inlet and outlet temperatures of the lubricating oil. The static pressures are recorded at three measuring psoitions equally distributed over the circumference of the in- and outlet planes of the turbocharger. The total inlet and outlet pressure of the turbocharger are calculated using the measured static pressure and the Mach number according to [5]. The temperature at the turbine side is measured by three Type K thermocouples with a sensor diameter of 3 mm which are distributed equally over the circumference of the measuring plane. On the compressor side the temperature at the in- and outlet are measured by means of three PT100 resistance thermometers with the same circumferential distribution. The total temperature is calculated according to [5] and experimental investigations of [6].

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